[0026] FIGS. **4**B and **4**C are schematic views of an actuator of an image display according to the fourth embodiment of the present invention.

[0027] The following discussion and the foregoing figures describe embodiments of Applicant's invention as best understood presently by the inventors however, it will be appreciated that numerous modifications of the invention are possible and that the invention may be embodied in other forms and practiced in other ways without departing from the spirit of the invention. Further, features of embodiments described may be omitted, combined selectively or as a whole with other embodiments, or used to replace features of other embodiments, or parts thereof, without departing from the spirit of the invention. The figures and the detailed description are therefore to be considered as an illustrative explanation of aspects of the invention, but should not be construed to limit the scope of the invention.

[0028] An apparatus according to this invention may compromise a substantially flat display that is oriented vertically or horizontally. The display has the added ability to dynamically exert a force or a sensation on objects that are placed on the display. This force can be used to move objects or create a specific texture, which fingers that touch the display can feel.

[0029] For example, a table may have a physically integrated image display according to the present invention, or the image display may be connected to the table or resting on the table. The image display may also be designed as horizontal screen with legs and further, may resemble a table or have function similar table, for example, when the image display is inactive or on portions of the surface without the image display. The image display may have the functionality of a touch-screen that can display a game board, such as a chessboard, upon which real chess pieces can be placed. The touch-screen of the display would then be able to sense what pieces are at what positions, by for example, if every piece had a slightly different bottom profile, so that the imprint is slightly different. The user can then have the experience of playing chess against a computer opponent. To keep the experience complete, the display may be able to move the chess pieces of the computer opponent as well, as described below. It will be understood that the present invention is also suitable for many other types of games, including games that require the motion of pieces such as those used in checkers, backgammon, scrabble, rumicubes, game tiles, cards, or the like.

[0030] A second example is where the display gives the user feedback when the screen is touched. For example, when pressing displayed "buttons" on the screen or on a virtual keyboard or keypad displayed on the screen. Such haptic feedback can also be content related. For example, a displayed lake could actually ripple when touched. Here the user's finger would be "moved;" the user would feel a force or a raised surface when the user pressed one or more finger on the display.

[0031] It will be understood that a touch-screen is not necessary for all embodiments of the present invention. Further, the display may be implemented as any kind of monitor, screen or display, including, for example, a CRT, an LCD, an LED, a plasma, a rear projection or front projection display or any other kind of flat or other type of screen or display suitable for performing in accordance with one or more embodiments of the present invention.

EMBODIMENT 1

[0032] A first embodiment of the present invention is shown in a cross-sectional view by FIG. **1**. A ball bearing **1-10** of a bearing ball assembly **1-1** is powered magnetically to rotate, and thereby move in a two-dimensional direction **1-30** an object (shown in FIG. **3**E as object **3-2**) at or near a surface **1-50** of the image display.

[0033] An activation of a driving magnet **1-21**, **1-22** is controlled by a control signal. According to an embodiment of the present invention, a set of driving magnets **1-21**, **1-22**, et cetera may be arranged. For example, FIG. **1** shows a set of three driving magnets, including driving magnets **1-21**, **1-22**, however, two or more additional driving magnets (not shown) could be provided "in front of" and "behind" the ball bearing **1-10**. In such an arrangement, activation of two or more driving magnets would cause rotation of the ball bearing **1-10** along either axes shown by the two-dimensional direction **1-30**, or along a vector that has components in both axes. Such ball bearing assemblies could be made small and arranged between pixels of the image display. According to an aspect of the present embodiment, ball bearing assemblies would not be included between every pair of adjacent pixels.

[0034] According to an embodiment of the present invention, ball bearing **1-10** has smaller magnets **1-11** arranged near a periphery thereof to improve control of the ball bearing **1-10**. It will be understood that the ball bearing **1-10** does not necessarily have to be a solid body. Further, while a ball bearing **1-10** is described, the present embodiment could also work with other types of substantially spherical bodies instead of or in addition to ball bearings. According to an aspect of the present embodiment, the ball bearing **1-10** used would have to be relatively small to be able to provide the maneuverability necessary to perform according to the present invention.

[0035] Accordingly, when for example, an object such as a chess piece requires movement, the control signal activated driving magnet **1-21**, **1-22**, would rotate the ball bearing **1-10** in a specified direction **1-30** along the surface **1-50** of the image display, causing the motion of the object along with the rotation of ball bearing **1-10** in the specified direction.

[0036] Further, it will be appreciated that longer motions of objects at the surface could be achieved by serial activation of ball bearings. For example, a time-delayed activation of adjacent ball bearings rotating in a similar direction would cause the object to experience continuous force, causing a longer movement. Also, the amount of electricity applied to magnetize the driving magnets **1-21**, **1-22** could also be controlled, based on the type of application (for example type of object to be moved: in chess for example, there are smaller and larger pieces), and the desired speed of the motion. Fine control over the timing of the activation sequence of the ball bearings could then effect acceleration, deceleration and speed control of the object near the surface.

[0037] More than one ball bearing **1-11** may be activated at any one time and several ball bearings in any one area of the image display could be used to move an object. Also, activation of ball bearings in various sequences could cause movement of the object in directions other than due east, due south, due west or due north. Similarly, an object trajectory resem-